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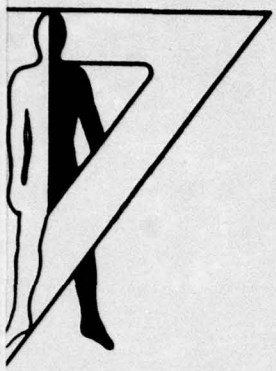

Technical Memorandum 31-76

PROFILING THE CHARACTERISTICS OF THE DEVELOPMENTAL TEST PARTICIPANT

James C. Geddie

October 1976
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U. S. ARMY HUMAN ENGINEERING LABORATORY
Aberdeen Proving Ground, Maryland

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The problem of differing DT and OT projections of performance and reliability in systems tests is addressed in terms of variation in human performance. Methodology is proposed for accounting for this variation by using (1) selection criteria for test participants and (2) biographical data describing the population from which they were sampled. An example of how the methodology might be applied is included.

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PROFILING[a] THE CHARACTERISTICS OF THE DEVELOPMENTAL TEST PARTICIPANT

INTRODUCTION

The data from developmental tests (DT) describing system[b] performance and system reliability often do not agree with data from operational tests (OT) conducted on the same system. The difference can originate from any combination of a number of sources which can be broadly categorized as (a) changes in the hardware being tested, (b) differences in the test methodology and conditions, and (c) the personnel who participated as users or operators of the hardware.

Changes in the hardware involved in the system might include wear, different combinations or configurations of components, or perhaps "fixes" which may have been implemented between DT and OT. Differences due to wear can be addressed by physical measurement of tolerances and documented by the amount of use the hardware has received. Different combinations or configurations of components should be a routine part of the description of the equipment in a system test. Any repairs or modifications of the equipment should also routinely receive thorough documentation. In short, although changes in the hardware would certainly be expected to impact on performance and reliability data, the changes themselves should not be difficult to identify.

The test conditions and methodology will almost always be different in DT and in OT, but are the subject of detailed description in the test plan. Procedures and guidelines for their implementation already exist for describing differences in test conditions and methods which might affect test results.

THE PROBLEM

The third category of differences—the influence of the human operator—has not been adequately addressed. At the present time there is no procedure built into the testing methodology for examining this source of variation. It is this gap in the methodology which is addressed in this proposal.

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[a]The term "profile" is used by the military in several different ways. The soldier's personnel records use it to describe a set of ratings of physical attributes. This usage refers to a physical profile (4). If the soldier has an injury or illness, the term special-duty profile specifies activities in which the soldier should not engage. Unless otherwise stated, the term "profile" as it appears in this report has a broader meaning than either of these usages. It refers to a set of physical and intellectual characteristics which may affect performance in system tests.

[b]The term "system" as used throughout this report should be understood to include the human operator.

PROPOSED SOLUTION

Because human performance influences the total system's performance, we need methods to control the variance contributed by the human operator. The most direct method of control is personnel selection. If participants in tests are selected according to criteria which eliminate personnel who fall at extreme ends of the distributions of values of relevant characteristics, variation in performance should be reduced accordingly. If this variation in performance has the effect of noise (in an information-theory sense) on measurements of system performance or reliability, reducing this "noise" should enhance our measurement procedures' sensitivity to the sources of variation which are the real subject of the test.

Once the sample of participants has been screened according to the selection criteria, the selected participants should be described in greater detail by means of biographical data. The collection of biographical data is not, in itself, a control on human variation. The benefit which accrues from this approach is that the evaluator has an a posteriori method of accounting for differences which are not attributable to other sources of variation.

A longer-run benefit from the proposed approach would be development of performance-based selection criteria. If a data base is built up consisting of characteristic descriptive data on test participants and the level of performance they attain on specific tasks in testing, by reviewing the correlation between task performance and descriptive data across participants we should be able to develop a profile of levels of these characteristics which are required by similar tasks in other systems. In addition to selecting test participants, the profile might also alert the evaluator when the system hardware requires a profile of operator characteristics which is unusual. In the early stages of development this information could serve as a check on system engineering and could identify problems at a stage of development when it is relatively inexpensive to make remedial changes in hardware design.

Selection Criteria

The basic purpose of the selection criteria is to eliminate extreme values of the selection characteristics. Although it would be desirable to have the characteristics of the sample of test participants distributed in the same proportions as in the population of interest on each variable, the criteria proposed here would serve only to reduce the sample variance. The requirements for the test participant should include specification of his required military training, his basic physical dimensions, and his perceptual abilities.

Training Requirements

The required MOS, complete with skill-level suffix, should be specified. This specification should include a determination of whether the specified MOS must be the participant's primary MOS or whether a soldier with this specialty in a secondary MOS is acceptable. If alternate specialties include the required training and are acceptable substitutes, these should also be listed. In addition, the training-requirements specifications should state whether the MOS must be a school-trained qualification or whether an OJT-qualified soldier meets the requirements.

Physical Dimensions

Minima and maxima for height and weight should be specified, giving due consideration to the range of these dimensions expected in typical users when the system is fielded. One approach might be to establish centile cutoff scores first for height, then determine upper and lower centile cutting scores for weight at each height. A graphic example of how this might be done is presented in the Appendix.

No personnel with a special-duty profile should be permitted to participate unless a task analysis reveals that the restriction on his activities has no impact on the tasks required in the test.

Sensory Acuity

All participants should have had a recent (within the last 12 months) test of vision and audition. Minimum standards should be stated for each of these sensory modalities depending upon an analysis of the requirements of the tasks to be performed. A good starting point for standards might be those required of new inductees into the Army. Although there is room here for the application of judgment in individual tests, standards should nonetheless be established and stated, together with their rationale.

Descriptive Data

After participants have been selected according to criteria, a more detailed description of their characteristics should be obtained by collecting the following information on each test participant:

1. Actual value for the participant on each of the selection criterion measurements.

2. Scores from aptitude tests administered when the participant first entered the Army.

3. Scores from the participants' most recent MOS tests.

4. Experience (in months) in the relevant MOS.

5. Total service time.

6. A list (by descriptive title) of additional system-related training or courses completed.

7. Results of tests administered during system-specific training.

8. Performance criteria applied during system-specific training, including:

   a. Minimum performance required, and

   b. Level of performance attained by the participant.

9. Civilian Education. Both the level attained and the specialty, if any, should be recorded.

The above items of information can be collected easily. Most of them are available from the participants' personnel files. Item one can be recorded for each participant as a part of the selection process. Items two through six should be available from personnel files. Items seven and eight should be a part of the system-specific training and can be collected at that time. Item nine may be up-to-date in personnel files, but this and other pertinent administrative data can be collected or confirmed via a simple data-collection form administered on the first day of the test.

While the relationship between each of the first eight items and soldier performance should be apparent, item nine is included because the education the participant brought with him into the Army may influence his performance. It would be useful to know, for example, whether the operator of a fire-direction center had a strong background in mathematics, drafting, computer science, or other related fields.

DISCUSSION

For the developmental tester and evaluator, one important benefit of this approach would be greater face validity of the test data. Because the selection of participants for operational tests often involves simply specifying a unit type, then allowing a U.S. Army Forces Command commander to select such a unit from the target population, the troops who participate in operational tests have some built-in believability: they are sampled (not randomly, and probably not representatively, however) from the user population. Participants in developmental tests often include civilian technicians in early stages of development. Soldiers who participate are selected on an individual basis and may be more experienced in DT participation than in the relevant MOS. Since these individually designated participants are not selected because they are members of a user-type unit (by definition, part of the user population) but are selected individually, they do not have the built-in believability enjoyed by their counterparts in operational tests. Thus, when DT and OT project different performance and reliability values, the operational tester appears to argue from a position of strength. If DT participants can be selected in a way that eliminates the extremes of the distribution, and if biographical data are available to describe the population from which they were sampled, suggestions that the differences between DT and OT are due to "test-wise" DT participants loses some of its credibility.

It would not be practical and might not even be desirable to try to select OT participants according to the same scheme. However, the comparability of test data between OT and DT could be enhanced by collecting biographical data on OT participants similar to that proposed above for DT participants.

The purposes of DT and OT are understandably different. As mentioned earlier, the test conditions and methodology will almost always be different. But if we include the human operator in the system concept, to test one time using civilian technicians and test-wise soldiers, then again using participants from the intended population, is to test two different systems. The utility of demonstrating that these two systems behave and perform differently is not compellingly apparent.

The concept of selection and description of test participants is not new. It has been applied in testing on a somewhat unsystematic basis for several years. The U.S. Army Test and Evaluation Command (TECOM) includes in many of its Materiel Test Procedures (MTPs) and Test Operations Procedures (TOPs) provisions for recording descriptive data on test participants.

In MTPs on human factors engineering (8) there are instructions concerning selection of test participants: "Make certain that the operators used in the evaluation represent those who will be operating the equipment in actual use, particularly with respect to such characteristics as age, general ability, experience and training." This is followed by a series of guidelines which include avoiding biased subjects and "expert operators", and recommendations that the tester "motivate the operators to the same extent they are likely to be motivated in future use of the system."[c]

Contractor Demonstration (CD) testing (5) often includes attempts to select and to describe test participants. Since January of 1972, contractors have been required (2) to include in their reports of human factors engineering tests a description of test participants. The most recent description requirement (3) includes recording for each participant age, weight, body dimensions relevant to performance tasks, visual acuity and hearing levels, any known physical disabilities, and score from a standardized measure of general intelligence. Tests conducted jointly with foreign governments have included similar requirements (6). Earlier applications of the concept include selection of personnel for training as rangefinder operators back in 1942 (7).

The point to be emphasized is that the present proposal does not represent a radical change in current materiel-testing procedures. Rather, it suggests that we impose some consistency upon procedures which previously have been followed with varying degrees of thoroughness. The Appendix gives an example of how the profile criteria might be applied and the descriptive data collected.

In conclusion, it is proposed that selecting developmental-test participants according to uniformly applied criteria, then describing in greater detail the population from which they were selected, offers a means of controlling the system performance variation contributed by the human operator. The effort required to implement this proposal appears small when compared to the benefits to be gained in the form of reduced variation between samples of operators and of enhanced accuracy in predicting system effectiveness in the field.

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[c]The quoted MTP is one of several which are concerned with human factors engineering. In addition to the personnel selection and description guidance in the human factors MTPs, many other MTPs and TOPs addressing specific classes of systems include lists of descriptive data which should be collected on developmental test participants.

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APPENDIX

The following application of the proposed selection criteria and biographical data collection is one example of how the criteria might be stated and the data obtained. This example is drawn from a proposal by the HEL Detechment (AMSAA) for selection of soldiers to participate in testing the Main Battle Tank XM-1. It is not intended as a general format to be followed in other tests, because each testing situation presents its own sets of requirements and constraints. However, there are certain facets of the task of specifying selection criteria which are common to most selection exercises, and the example may prove useful by analogy.

A. The specific selection criteria for SOMTE personnel are:

1. Training Requirements

Participants must have a primary, school-trained MOS of 11E, with at least 6 months of functional experience in the crew position assigned for the test (e.g., driver, gunner, loader, commander). Participants' skill-level suffix should be no higher than the minimum required by TOE for the assigned position.

2. Physical Requirements

Personnel height must be within the 5th to the 95th percentiles for height of armor crewmen. Their weight must be within the 5th to the 95th percentiles for their height. Figure 1A illustrates graphically the acceptable height and weight values. In addition, the participant should have a rating of "one" in each of the six factors (PULHES) of the physical profile serial system (4) unless it can be determined from a task analysis that any limitations on one or more of the factors will not affect test results. As an example, a numerical rating lower than "one" for vision (E) would not be acceptable in a gunner, driver or commander, but might be acceptable in a loader.

3. Perceptual Requirements

All participants should have had a physical examination within the last 12 months, including tests of vision and audition. If the examination data are older than 12 months, tests of vision and audition must be conducted to validate the profile rating for PULHES factors H and E.

The training-requirements statement allowed only a primary, school-trained MOS of 11E and 6 months of functional experience. Note that the skill-level suffix is limited to the lowest level specified by TOE. For example, the driver and loader must have 11E10. The gunner can be no higher than 11E20, nor can the commander be any higher than 11E30. Although this may seem unnecessarily restrictive, it seems unlikely that the XM-1 system will operate tactically with a crew that is highly overqualified. To test it using an overqualified crew would therefore be to test a different system.

The cutting values for height and weight (Figure IA) were drawn from MIL-HDBK 759 (1) and are based on a 1966 sample of Army men. The height limits for the 5th and 95th percentiles were established first. Then the 5th and 95th percentile weights were calculated for each of the extremes of the acceptable height range. The four points thus obtained are the corners of the acceptable height and weight figure. The figure would include about 81 percent of the 1966 sample. To the degree that the population of Army men has changed in height and weight over the past 10 years, the cutting scores used here are inappropriate. One would therefore be able to present valid arguments for other sets of cutting scores. The present scores were based on the latest generally available data.

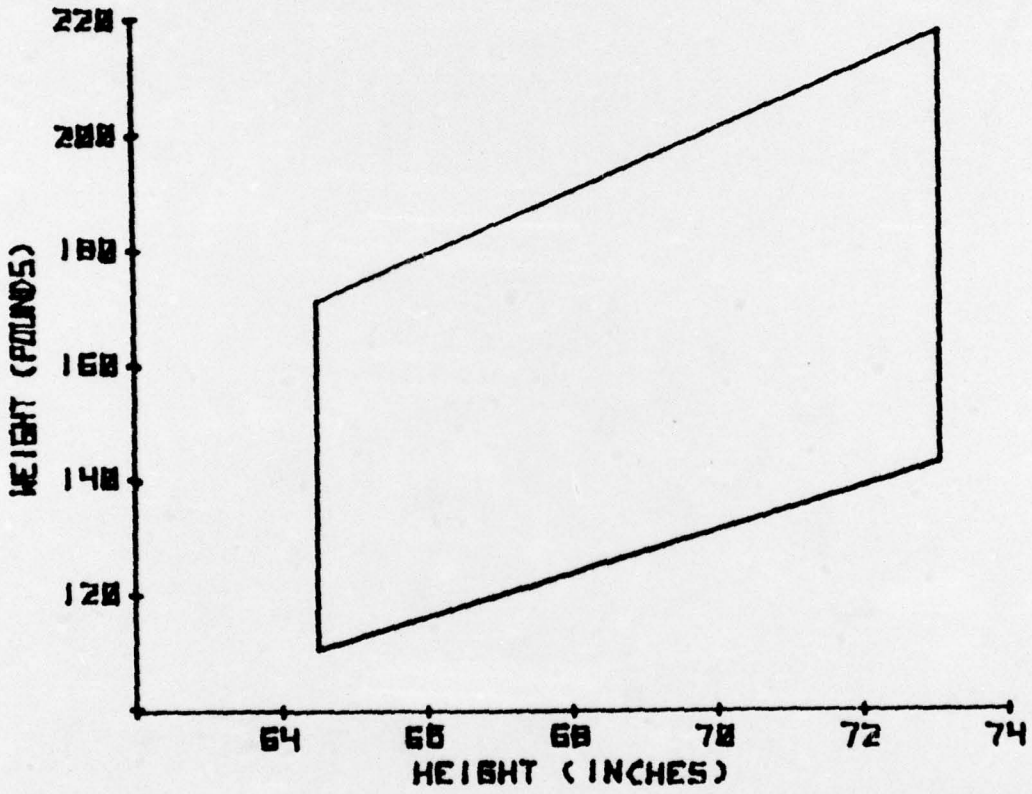

Figure 1A. Acceptable values for height and weight.

B. Descriptive data on each participant may be collected on Form 1.

The descriptive data required on the Personnel Data Form are divided into two sections. Part A includes items which the test participant can provide from memory. The items in Part B can be obtained by test-control personnel from the soldier's Personnel Qualification Record, Part I (DA Form 2) and Part II (DA Form 2-1).

If personnel data are retrievable by name or by social security account number, as in items 1 and 4 of Form 1, an appropriate privacy-act disclosure statement should be prepared according to guidelines in OMB Circular No. A-108, which defines responsibilities for implementing the Privacy Act of 1974 (Public Law No. 93-579, 5 U.S.C. 552a).

FORM 1

PERSONNEL DATA FORM

A. To be completed by test participant.

1. NAME _____ 2. DATE _____

3. MOS _____ 4. ID No. _____

5. Crew Position (in the test) _____

6. Months of experience (in tested crew position) _____

7. Height _____ 8. Weight _____ 9. Date of birth _____

10. Length of service: _____ years, _____ months

11. Civilian Education: (a) 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 (circle number of years)

b. Major area (if applicable): _____

B. To be completed for each participant by test control personnel.

12. Physical Profile:

P	U	L	H	E	S

13. Aptitude Scores: (a) CO _____ (b) FA _____ (c) EL _____ (d) OF _____

(e) GM _____ (f) MM _____ (g) CL _____ (h) ST _____ (i) GT _____

(j) SC _____ (k) EI _____ (l) GI _____ (m) CI _____ (n) AD _____

(o) SK _____ (p) TI _____ (q) AI _____ (r) AP _____ (s) PA _____

(t) MK _____ (u) WK _____ (v) AR _____ (w) MC _____

14. Latest MOS test score: _____

15. End-of-training test score: _____

16. Minimum performance (a) required: _____ (b) attained: _____

17. List of military schools and courses completed:

_____

_____

_____